13/12/18.

UNIT - II

Abstractions from Precipitation.

When precipitation comes to the earth surface it the produces runoff. The runoff is important for study & to design the hydraulic structures and estimating floods. All the precipitation that comes to the earth surface doesnot contribute the runoff some part of it disapper. The loss of it occurs due to evaporation, Transpiration, Interception, depression storage and Infiltration, there are called as Abstractions from Precipitation.

Interception.

When a rain falls it is firstly intercepted by trees, plants, buildings etc..... When they become completely wet the water comes down to the earth surface.

- The initial water intercepted by trees, buildings and plants etc.... is required to wet them and after that the water intercepted by equals evaporation rate. So this complete amount of water is called "Interception Loss", and it is denoted by

$$x = a + bt$$

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x = total interception

a = water required for wetting

b = evaporation rate from the intercepting surface (cm/hr)

t = Duration in hours.

- Vegetation to cover on the ground, buildings roads and pavements intercept part of the fall in precipitation and temporary stored on their respective surface this intercepted water is either evaporated back into the atmosphere are mostly falls down to the ground.
- Normally water from the roof of a building is let into a drainage system (or) into the subsoil via sewers and storm drains

* Depression Storage:

When the precipitation reaches to the ground primarily it must fill all the depresions before it can flow over the surface. The volume of water trapped in these depression doesnot contribute to the runoff so these are called "depression storage."

- These depression storage depends on many factors such as
  1. The type of soil
  2. Condition of surface
  3. Nature of depression
  4. Slope of catchment
- From the experiment on different soil we are able to take some values for depression storage loss during intensive storms.

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1. Sand - 0.5cm
2. Loam - 0.4cm
3. Clay - 0.25cm

* Watershed Leakage:

Adjust basins are seperated by ridge lines Sothat rainfall falling over a basin flows towards the drainage lines (Ex: Streams of the basin). Watershed leakage may be defined as flow of water from one basin to another basin (or) from one basin to the sea through major faults (or) other geographical features.

* Evapolation:

Evapolation is the proces in which a liquid changes to the gaseous state at the freesurface below the boiling point through the transfer of heat energy. It is a continous natural proces by which substrance changes from liquid to gaseous state.

The main source of evapolation is the solar radiation The rate of evapolation is depended on the following factors.

1. Vapour pressure
2. Nature of evaporating surface
3. Area of water surface
4. Depth of water bodies
5. humidity
6. Wind velocity
7. Temperature of air
8. atmospheric pressu
9. Quality of water.
10. Nature & size of evapolatig surface

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14/12/18

* Nature of evaporating surface:

Different evaporating surfaces like soil, forest area, houses and lakes effect evaporation to the extend they have the potential. Blackcotton soils help to evaporate the soil water faster than redsoil because such soils have the potential to absorb incoming radiation more effectively. Evaporation from wetsoil is faster and it reduces gradually as soil becomes dryer.

* Area of water surface:

In evaporation loss directly depends upon the area of the water surface, greater the area greater will be the waterloss due to evaporation

* Depth of water in waterbody:

Deep water bodies evaporates slower than shallow waterbodies in summer. while in winter season their evaporates faster

* Humidity

Evaporation is inversely proportional to the humidity If the humidity in the atmosphere is more evaporation will be less.

* Wind speed | velocity

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Wind removes the overlaying member vapour from an evaporating body there by increase the rate of evaporation However high wind speed may not

necessarily remove watervapour from a small waterbody. There is a relation between the wind speed & size of the waterbodies' are evaporating surfaces.

* Temperature:

Increase in air temperature increases the evaporation rate so not always proportionately for the same temperature coolder once have less evaporation than summer once due to combined effect of other environmental parameters.

* Atmospheric pressure:

The evaporation will be less if the atmospheric pressure is more. Thus at higher altitudes evaporation loss is more while in deep valleys evaporation is less.

* Quality of water:

The presence of dissolved salts in water reduces the saturation water pressure of water which consequently reduces the rate of evaporation. For example the Bay of Bengal has salt concentration of 3.15%. and its evaporation rate is nearby 3% less than the evaporation from freshwater.

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Measurement of Evaporation:

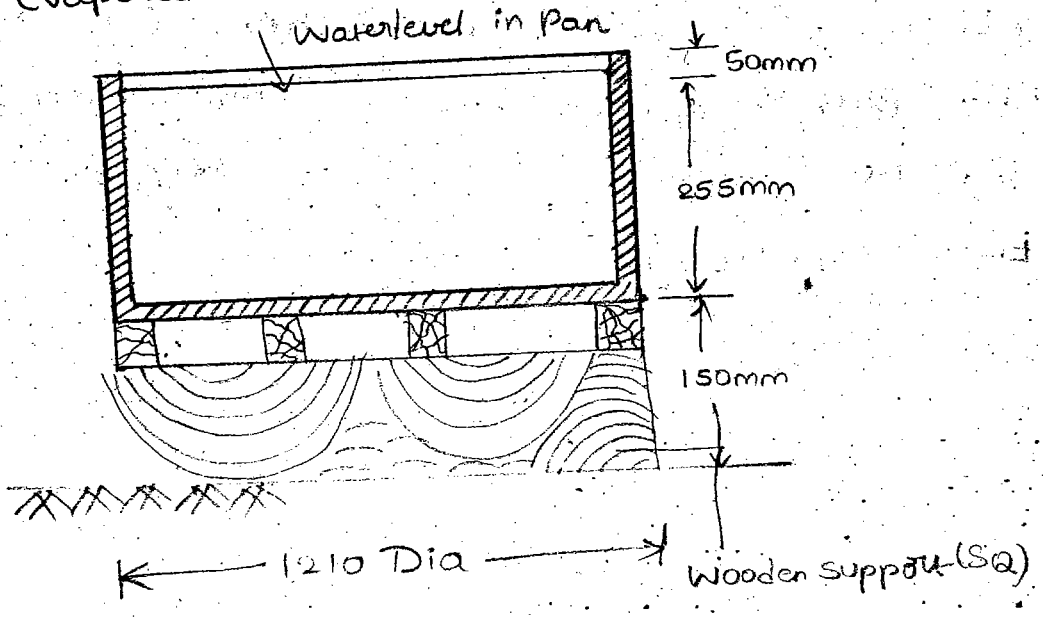
Estimation of evaporation is of very much importance in many hydrologic problems like planning and operation of reservoirs and irrigation systems. The amount of water is estimated from a watersurface by the following methods

1. Evaporemeter Data
2. Empirical evaporation equation
3. Analatical method

* Evaporemeter Data:

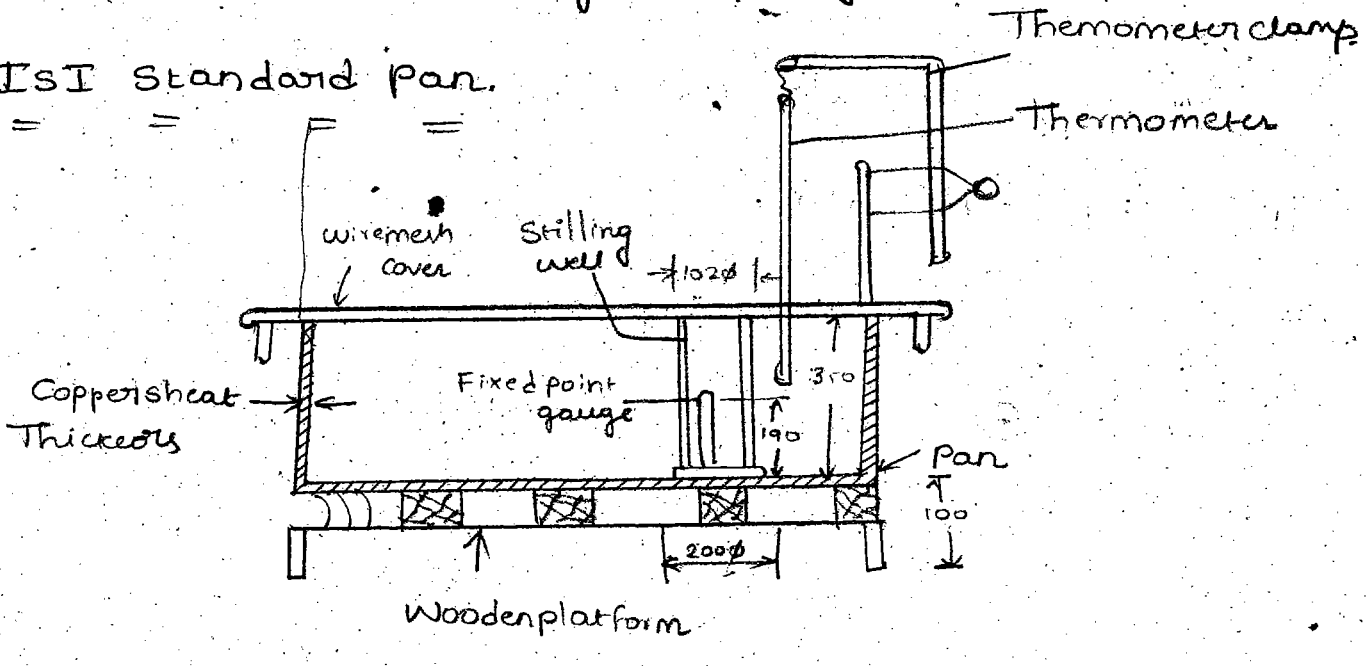
Evaporemeter Data are water containing pans which are exposed to atmosphere and the loss of water by evaporation in them is measured. in practice many evaporemeter are used Some of them are

1. Class-A evaporation pan



The pan is madeup of unpainted galvanized iron sheet and the metal is used where corrosion poses a problem. It is mainly used by US weather Bureo.

* ISI Standard pan.



This pan evaporameter is also known as modified class A pan. This pan is made of copper sheet, tinned inside and painted white outside. The top of the pan is covered fully with a hexagonal wire netting of galvanized iron to protect the water in the pan from birds.

The presence of a wire mesh makes the water temperature more uniform during day and night The evapotation from this pan is 14% lessthan class A evapotation

* Emperical Equations

A large number of emperical equations are available to estimate the lake evaporation using commonly available meterological data. Using Emperical Formula:

1. Meyer's formula:

$$E = K_m (e_s - e_a)\left(1 + \frac{V_9}{16}\right)$$

Where E = evapolation from body water body in mm/day

e_s = Saturation vapour pressure at the water surface temperature in mm of hg

e_a = Actual vapour pressure of overlying there in mm of hg at specified height (9m)

K_m = Coefficent having value of 0.36 for large deeper water bodies and 0.5 for Shallow water bodies

V_9 = Velocity of air at there specified height 9m

2. Rohweri's formula:

$$E = 0.771\,(1.465 - 0.000732\,P_a) \times (0.44 + 0.0733\,V_{0.6})\,(e_s - e_a)$$

E = Evapolation from waterbody in mm/day

P_a = Mean atmospheric pressure i.e Barometric reading in mm of hg

$V_{0.6}$ = Mean wind velocity in km/hr at ground level which can be considered as 0.6m above ground

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One-Seventh Rule:

To estimate wind velocity at any height Z_2 from known wind velocity at Z_1 is as follows

$$\left(\frac{V_1}{V_2} = \frac{Z_1}{Z_2}\right)^{1/7}$$

(iii) Water budget Method:

$$P + Q_i \pm Q_u = E + Q_o \pm \Delta Q_s$$

P = Total precipitation on the water surface

Q_i = Total surface in flow

Q_u = Total underground inflow / outflow.

E = Evaporation

Q_o = Surface outflow.

ΔQ_s = Change in storage.

* Methods to reduce evaporation losses:

There are various methods to reduce the evaporation from surface of water bodies

1. * Reduction of surface area.

The volume of evaporated water is directly proportional to the surface area of the water body. So we try to reduce the surface by making the water body more deeper.

2. * Mechanical power: www.Jntufastupdates.com

Evaporation occur when the sunlight reach to the surface of water body so by providing the mechanical [illegible] will protect the surface of waterbody

from direct sunlight.

3 * Chemical cover:

This method consist of applying a thin film on the water surface to reduce the evaporation This film reduces moment of water particles which leaves the surface after settling energy

4 * Increase Salinaty

As we know if the salinaty is more then evapotation is less so by increasing salinity we can reduce the evapotation.

18/12/18.

* Transpiration

Transpiration is the proces by which the water leaves the body of a living plant and reaches the atmosphere as water vapour. The water leads the plant from it's leafes and stomata. The transpiration occurs when the proces of photo synthesics is run As this process occurs in daytime only. The maximum transpiration occurs only on daytime (around 95%.)

The important factors which effect the transpiration are as follows

1. Atmospheric Vapour press

3. Wind
4. Light intensity
5. Characteristic of plant

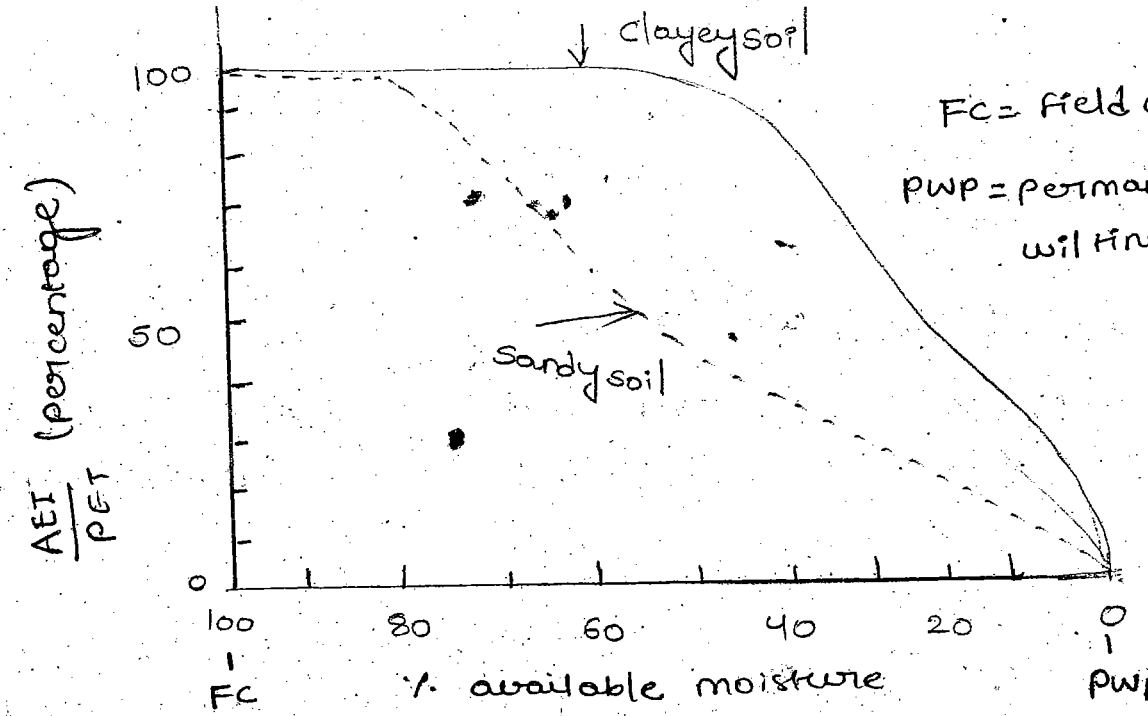
* Different plants will obidently transper different amount of water and their water consuming characteristics are compared by the transpiration ratio.

$$\text{Transpiration ratio} = \frac{\text{Total mass of water transpired by the plant during its full growth}}{\text{Mass of dry mater produced}}$$

- Transpiration ratio will increase if the water requirement of a crop increases. Transpiration ratio for wheet is 300-600 and for rice is 600-800

* Evapotranspiration

When the transpiration takes place the land area in which plants stand also loose moisture by the evapotation of water. Since in the process of vegetation growth it is not possible to seperate the transpiration and connected evapotation from the plants surrounding. So the evaporation and transpiration are considered under one head called as "Evapotranspiration."



- For a given set of atmospheric condition evapotranspiration mainly depends on the availability of water
- When sufficent moisture is freely available to completely meet the needs of the vegetation fully covering the area, the result in evapotranspiration is called potential evapotranspiration (PET)
- The real evapotranspiration occur in in a specific situvation in the field is called Actual evapotranspiration (AETP)
- PET mainly depends upon climateological factors rather than on characteristics of plants and soil while AETP is largely effected by the characteristics of soil and vegetation.
- The water supply is adequate for plant soil moisture at field capacity at the staige AETP will be equal to PET. If the soil moisture is reduced then

AET by PET ratio will be less than unity.

$$\frac{AET}{PET} = 1$$

- For clayey soils AET/PET ratio will be nearly to unity when the available moisture is depleted to upto 50%.

- In hydrology we use PET as a basic parameter in various estimation related to water utilization connected with evapotranspiration process.

* Definitions

Field capacity:

Feild capacity is the maximum quantity of water that the soil can retain against the force of gravity

Permant wilting point:

It is that moisture content of a soil at which moisture is no longer available insufficent quantity to sustain the plants. The moisture in soil is tightly bonded with soil grain such that the plant cannot exract the water from it.

* Available Moisture:

The difference b/w the moisture content of field capacity & PWP is called available moisture which can be easily extracted by the plant

* Measurement of Evapotranspiration:

The measurement of Evapotranspiration is Very much important in hydrology the measurement can be done by

1. Mabiy Model
2. Evapotranspiration equations
3. Empeical equations.

* Mabiy Model:

It can be found out by two model methods

1. Lysimeter

A Lysimeter is a special water ~~tight~~ tank containing a block of soil and set in a field of growing plants. The plants grow in the lysimeter (or) same as the surrounding field. The evaporation is estimated in terms of the amount of water required to maintain constant moisture conditions within the tank. and is measured by an arrangement made in Lysimeter.

A Lysimeter should be design to accurately reproduce the soil condition, moisture content, type & size of the vegetation of the surrounding area

- Lysimeter studies are time consoming & expensive.

2. Field plots:

A plot is choosen and all the elements like precipitation, irrigation input, surface runoff, soil moisture, and percolation is measured.

- Evapotranspiration = Precipitaton + Irrigation input − runoff − Increase in soil storage

- As the measurement of percolation is a very difficult task in actual field problem so we keep the moisture level of soil at field capacity

* Evapotranspiration equations

In the Evapotranspiration equations the most used equation is Penmans equation.

Penman's equation.

This equation is baxed on sound theoritical reason and is obtained by combination of energy balance mass transfer approach

$$PET = \frac{A H_n + E_a r}{A r}$$

Where PET = Daily potential Evaporation Transpiration

A = Slope of the saturation vapour pressure Vs Temperature curve at the mean air temperature (in mm of Hg per degree centigrade)

H_n = Net gradiation (in mm of evaporable water per day)

E_a = Parameter including wind velocity & saturation deficeit.

γ = Psychometric constant (0.49mm of Hg/°c)

20/12/18.

* A Reservioul with a surface area of 300 hectares has the following average metrological values during a given week. R.H = 50% at temperature of 30°c. Wind velocity at 1mt above ground is 12 km/hour Mean baromemic reading 750mm of Hg. Saturation vapour pressure at 30°c is 31.82mm of Hg Estimate the average daily evaporation from this reservioll and volume of water evaporate during this week (use Meyer's & Rohwer's formula).

Sol^n: Given data;

Reservioul surface area = 300heactor

t = 30°c

R.H = 50%

e_s = 31.82mm of Hg

V_1 = 12km/hour

Mean Baromemic readig P_a = 750mm of Hg.

Km = 0.36

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Meyer's formula:

$$E = K_m(e_s - e_a)\left(1 + \frac{V_9}{16}\right)$$

$$e_a = R.H \times e_s = 0.5 \times 31.82 = 15.91 \text{ mm of Hg}$$

$$V_9 \geq \frac{V_1}{V_9} = \left(\frac{1}{9}\right)^{(1/7)} = \frac{12}{V_9} = 0.730,$$

$$V_9 = 16.42$$

$$E = 0.36(31.82 - 15.91)\left(1 + \frac{16.42}{16}\right)$$

$$E = 11.60 \text{ mm/day}$$

Total quantity of water evaporated

$$Q = \frac{11.60}{1000} \times 300 \times 10^4 = 34800 \times 7$$

$$Q = 243600 \text{ m}^3$$

* Rohwer's formula:

$$E = 0.771(1.465 - 0.000732)(0.44 + 0.0733 V_{0.6})(e_s - e_a)$$

$$V_{0.6} = \left(\frac{V_{0.6}}{V_1}\right) = \left(\frac{0.6}{1}\right)^{1/7} = 0.929$$

$$\frac{V_{0.6}}{12} = \left[\frac{0.6}{1}\right]^{1/7}$$

$$V_{0.6} = 11.15 \text{ km/hr.}$$

$$E = 0.771\{1.465 - 0.000732(31.82)\}\{0.44 + 0.0733 \times 11.15\}\{31.82 - 15.91\}$$

$$E = 14.12 \text{ mm/day}$$

$Q = \frac{14.12}{1000} \times 300 \times 10^4 = 42360$

$Q_1 = 42360 m^3$ (per day)

$\therefore Q_7 = 42360 \times 7 = 2,96,520 m^3$ (per week)

∴ Total quantity of water per day $= 42360 m^3$

∴ Total quantity of water per week $= 2,96,520 m^3$.

* Infiltration:

It may be defined as the downward moment of water from soil surface into the soil mass through the pores of the soil.

In simple terms infiltration is the entry (or) passage of water into the soil through soil surface. Once water enters into the soil the process of transmission of water in the soil known as "Percolation."

Infiltration is a major process continously effecting the magnitude timing & distribution of surface runoff of a basin

* Infiltration Capacity:

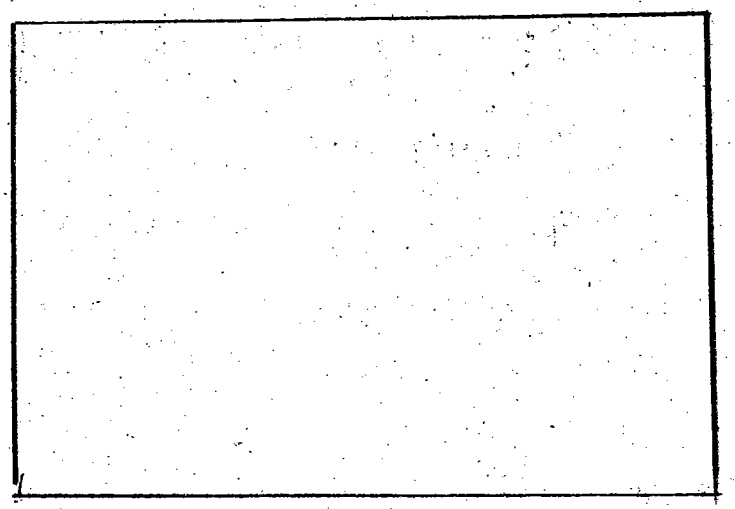
The capacity of any soil to absorb water from rainfalling continously at an excessive rate goes on decreasing with time until a minimum rate to infiltrate is reached. At any instant the infiltration capacity of a soil is the max. rate at which the soil in a given condition

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* Effects of Infiltration:

- It reduces the magnitude of the flood
- It delays the time of arrival of water to the channel.
- It recharges the ground water reservior.
- It reduces soil erosion
- It fills the soil pores to it's field capacity thus making water available to plants.
- It sustains green vegetation cover on the ground surface thus helps in reducig dust storms.

24/12/18.



* Factors effecting Infiltration:

1. Condition of entry surface (Vegetation cover for Bare land)

If the area is covered by grass, Vegetation & Bushy plants the infiltration capacity will be more.

→ Retarding surface flow and thus allowing more time for water to drain under the soil

→ Sheild in the soil surface from direct impact of raindrops because rain drop causes compaction and reducing infiltration capacity

→ The root system of the vegetation makes the soil more permeable and thus encourage more rapid passage of infiltrating water.

* Spreading of building and paved surface in urbanares effectively reduces the infill

2. Permeability (or) Percolation characteristics of soil formation

The infiltration will continue only when percolation continue. The infiltrated water must be transmitted down by the force of gravity and capillary action

The percolation however depends upon several factors such as soil & it's composition, permeability, porosity, stratification presence of organic matter and presence of salts.

* Moisture conditions in soil:

The infiltration rate will depend on initial moisture conditions of soil. When the soil moisture is high the infiltration rate will be low. When water falls on a dry surface the upper surface becomes wet while the lower parts of the soil remain comparatively dry initially. The results in a large difference of capillary potential, due to which a downward force will act on the water in addition to the normal force of gravity.

Temperature

The viscosity of water changes with temperature. The flow of water within the body of the soil is laminar and the flow is directly related to viscosity. In summer the infiltration will be higher due to less viscous water. in comparison to winter.

Intensity and duration of rainfall:

When the precipiton takes place with heavy intensity the impact of water caures mechanical compaction of fine particles, resulting in faster decrease in the rate of infiltration. However rainfall of lesser intensity result in higher infiltration rate. The rainfall with higher duration will result in lower infiltration in comparision to the same quantity of rain falling as 'n' number of isolated stones.

Movement of Man and Animals:

When there is heavy movement of man (or) animals the soil gets compacted resulting in reduction in the infiltration rate.

Change due to human activites;

Cultivation of baren land by growing crops and grass cover results in increasing rate of infiltration. On the other land construction of roads, houses, factories, playgrounds results in reduction in infiltration capacity

Quality of water

Silts and other impurities present in incoming water result in retardation of infiltration rate due to clogging of soil pores. The salts present in water affect the viscosity of water and may react with soil to form complexes that reduce the porosity of soil.

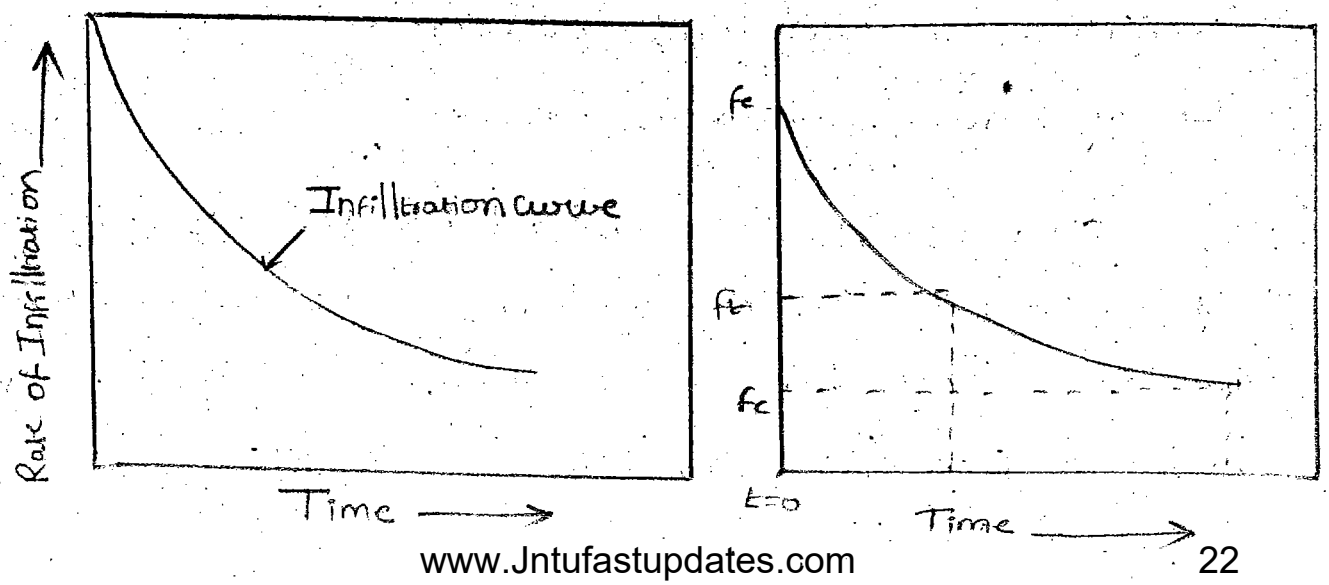
Presence of Ground water Table

In presence of GW Table reduces infiltration. For infiltration to continue in position of GWT should not be very close.

Size and characteristics of soil particles:

The infiltration rate is directly proportional to the grain size (or) diameter for granular soil. However if the soil has swelling minerals like illite, the infiltration rate may reduce drastically

* Infiltration Capacity Curves



26/12/18.

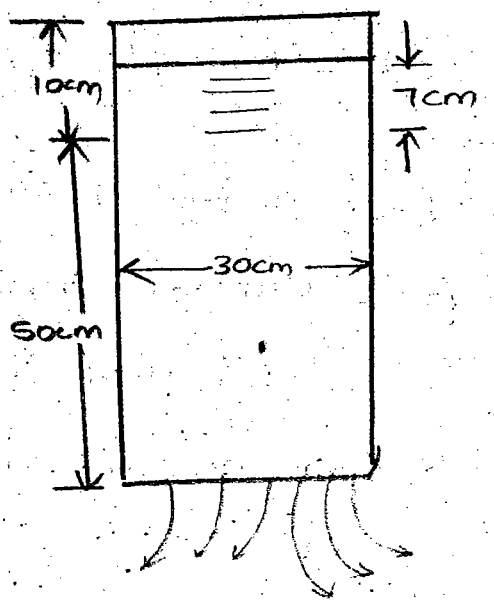
* Field measurement of Infiltration rate:

It can be measured with two types of Infiltrometers

1. Single tube infiltrometer
2. Double tube Infiltrometer

1. Single tube Infiltrometer

It consist of a hollow metal cylinder of 30cm diameter, 60cm length with both ends open The cylinder is driven in the ground such that 10cm of it projects above the ground. The cylinder is filled with water such that a head of 7cm within the infiltrometer is maintained above ground level. Due to infiltration of water the water level in the cylinder will hope on decreasing. Water is added to the cylinder through graduated jar (or) Burette so as to maintain constant level The volume of water added over a pre determined time interval gives the infiltration rate for that time interval.

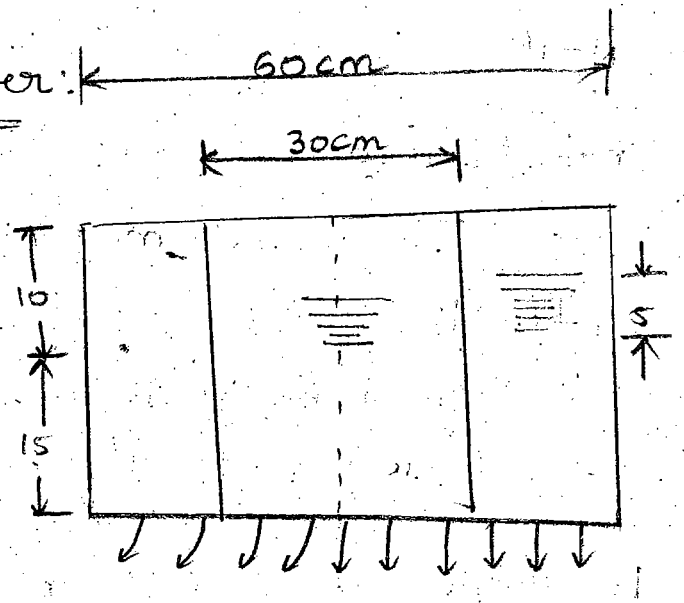


The observations are continued till almost uniform infiltration rate is obtained, which make take about 3-6hrs depending upon the type of a soil.

Infiltration rate

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2. Double tube Infiltrometer:



This infiltrometer consists of two concentric hollow rings driven into the soil uniformly without any tilt and disturbing the soil to the least depth of 15cm. The diameter of the rings may vary from 25-60cm. water is applied in both inner & outer rings to maintain a constant depth of about 5cm. The water depth in the inner & outer rings should be kept the same during the observation period.

By using of Empirical Equations:

Horton's equation:

$$f_t = f_c + (f_o - f_c) e^{-Kt}$$

Where

f_t = infiltration rate at any time t

f_c = constant infiltration rate at time $t = T$ (say)

f_o = Infiltration rate in the beginning ($t = 0$).

K = a constant which depends on the soil and vegetation.